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(54) IMPROVEMENTS IN OR RELATING TO REINFORCED CONCRETE CEILINGS

(71) I, HORST WOLF, a German citizen, of 26 Petrarcastrasse, 8, München, 45, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to reinforced concrete ceilings.

According to the present invention, we provide a method of producing a reinforced concrete ceiling comprising the steps of: forming at least one prefabricated ceiling unit which includes a concrete frame having longitudinal members and cross members defining a plurality of spaces, and hollow bodies which have upper and side walls and which are located over the spaces and are secured to adjacent longitudinal and cross members, and which has been reinforced to permit conveyance thereof prior to erection; erecting said at least one ceiling unit; and pouring concrete at least between adjacent bodies before or after erection of said at least one ceiling unit.

Further according to the present invention, there is provided a pre-fabricated ceiling unit for forming at least a part of a concrete ceiling, said unit comprising a concrete frame having longitudinal members and cross-members defining a plurality of spaces, and hollow bodies which have upper and side walls, and which are located over the spaces and are secured to the adjacent longitudinal and cross-members, and a reinforcement to permit conveyance and erection of the ceiling unit.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:—

Figure 1 is a plan of a prefabricated ceiling unit in accordance with the invention;

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Figure 2 is a section taken on line II—II of Figure 1;

Figure 3 is a section, to an enlarged scale, taken on line III—III of Figure 1;

Figure 4 is a cross-section of a forming table on which the ceiling unit shown in Figure 1 is produced;

Figure 5 is a fragmentary perspective view incorporating two different embodiments of ceiling unit in accordance with the invention;

Figure 6 is a section, to an enlarged scale, taken on line VI—VI of Figure 5;

Figure 7 is a side elevation, to an enlarged scale, of part of the ceiling unit shown in Figures 5 and 6;

Figure 8 is a section, to an enlarged scale, through part of the ceiling unit shown in Figures 5 to 7, prior to its completion;

Figure 9 is a section similar to Figure 8, after completion; and

Figure 10 shows a portion of the reinforcement of a plaster base of the ceiling unit shown in Figure 5.

As shown in Figures 1 to 4, a prefabricated ceiling unit 1 has a rectangular base equal in size to the whole or part of that of a reinforced-concrete ceiling to be formed. For example, the ceiling unit 1 can be 4 to 6 metres long and 2 to 3 metres wide.

The principal components of the ceiling unit 1 are a concrete frame 2 having longitudinal members 2*a* and transverse or cross-members 2*b*, between which are rectangular openings or spaces 2*c*, and hollow bodies in the form of inverted trough-shaped liners 3 having an upper wall and side walls and which cover the openings 2*c* between adjacent longitudinal and cross-members. The liners 3 are rigidly secured to the members 2*a* and 2*b* of the frame 2. In Figure 1, the liners 3 have been cut away horizontally, to enable the openings 2*c* in the frame 2 to be seen. The shape of the liners 3 can be seen

more clearly, however, in Figure 2 and 3. In the embodiment shown in Figures 1 to 4, the liners are made in one with the concrete frame 2 by a method to be described later. It is also possible to prefabricate the liners —from different materials, if desired, but preferably also from concrete—as will appear from the description of another embodiment of the invention.

As can be observed from Figures 1 and 2, the members of the frame 2 are widened in the vicinity of the end edges by which the ceiling unit 1 is supported, to form a peripheral laying or support flange 2*bb* which can withstand the bearing stresses encountered in use.

The ceiling unit 1 is provided with static reinforcement which, in the embodiment shown in Figures 1 to 4, consists of reinforcement elements in the form of girders 4 (which are preferably welded lattice girders or the like), seen most clearly in Figures 2 and 3. The girders 4 have a top flange 4*a* and a bottom flange 4*b*, joined together by a lattice web 4*c*. The bottom flange 4*b* is cast into the longitudinal members 2*a* of the concrete frame 2 and the top flange 4*a* together with most of the web 4*c*, projects freely into the trapezoidal space defined between the opposed longitudinal walls of two adjacent liners 3. In a preferred arrangement, the top flange 4*a* extends upwardly beyond the liners 3. In addition, substantially V-shaped reinforcing saddles 5 are incorporated in the longitudinal members 2*a*, the saddles 5 passing under the bottom flange 4*b* of the relevant girder 4 and having their upper end portions bent over sideways to extend over the liners 3 as shown in Figure 3. Reinforcing rods 6 are incorporated into the cross-members 2*b* and into the edge portions 2*bb* to provide transverse stiffness.

Wooden nailing battens 7 are incorporated in the longitudinal frame members 2*a*, in which they are anchored by hooks 8 projecting into the concrete.

The liners 3 are reinforced with a light wire meshwork, 9, which, along the lower edges of the liners 3, has projecting end portions 9*a*, extending into, and anchored within, the longitudinal members 2*a* and the cross-members 2*b* (Figure 3).

The ceiling unit illustrated in Figures 1 to 3 is produced as follows:

Moulds 11 (Figure 4) of the same shape as the inside of the proposed liners 3, are secured to a level-topped forming table 10, spaced apart according to the widths of the longitudinal members 2*a* and the cross-members 2*b* of the frame.

The battens 7 are laid in the space between adjacent moulds 11 and between the moulds and a vertical edging strip 12 on the forming table 10. In addition, the reinforcements consisting of the girders 4, the saddles 5 and the rods 6 are temporarily secured within the aforesaid spaces. The liner reinforcing meshworks 9 are fitted over the moulds 11. Then concrete is poured into the spaces between adjacent moulds 11 and between the moulds 11 and the edging strip 12. This concrete forms the frame 2 around the outer periphery of the bottom edges of the moulds 11, at the same time encasing the bottom flanges of the girders 4, the lower portions of the saddles 5, the rods 6 and the projecting end portions 9*a* of the liner reinforcements. The battens 7 are also anchored within the concrete. The liners 3 are formed at the same time; for this purpose, a portion of the concrete within the spaces between the moulds 11 can be spread over the moulds 11 or alternatively additional concrete can be sprayed on to the moulds 11 from above until the thin-walled liners 3 have been formed, the mesh reinforcements being embedded in the thin layer of concrete. In this manner an integral concrete structure is formed which contains its full complement of reinforcement.

Once the concrete has set, the ceiling unit 1 can be transported to the site without any special precautions. The girders 4 provide sufficient rigidity for the ceiling unit 1 to be loaded and laid with ordinary lifting tackle. On site, concrete is poured onto the ceiling unit, preferably up to the level indicated by the line 0 in Figure 3, and will encase all the reinforcing members projecting upwardly from the longitudinal members 2*a* and will preferably provide a covering over the tops of the liners 3, giving a floor or roof.

The main difference between the embodiment shown in Figures 1 to 4 and that shown in Figures 5 to 10 is that, in the latter, the lower surface of the ceiling unit 1 carries a flat plaster base 14, and the liners 3^1 are separately prefabricated and are then bonded to the longitudinal members 2^1a and cross-members 2^1b of the frame 2^1.

This ceiling unit 1 is made as follows:

To start with, the material for the plaster base 14, namely cement, plaster and/or concrete, is applied to the level surface of the forming table. A mesh of thin wires, 15 (Figures 6 and 7) is embedded in the plaster base 14. It should be emphasised that the plaster base 14 has no static function whatever in the ceiling unit 1, its thickness only being about 1.5 to 2 centimetres. The wires 15 serve only to hold together the layer of plaster forming the plaster base 14. In addition to the wires 15, rods 16 are embedded in the plaster base and have loops 16*a*, which project upwards at regular intervals from the base 14. Likewise, the rods 16 have no static function to perform in the ceiling unit 1.

The arrangement of the rods 16 in relation

to the wires 15 is shown in perspective in Figure 10.

The liners 3^1 are separately made from some suitable material, preferably concrete, or alternatively, for example, resin-bonded wood shavings, plastics, fibreboard or woodwool bonded with cement or magnesite. The liners 31 are arranged, suitably spaced, on the plaster base 14 while the base 14 is still "green", i.e. the material used for the plaster base 14 not having set. The bottom rims of the liners 3^1 thus sink into the plaster base 14, as can be seen in Figure 8. This produces an intimate bond between the plaster base 14 and the liners 3^1, which can be improved still further by arranging for the projecting end portions 9^1a of the liner reinforcements 9^1 to extend from the rims of the liners 3^1 and be bedded into the plaster base 14.

Then, concrete is poured from above between the liners. As can be seen in Figure 9, this concrete forms the longitudinal members 2^1a and the cross-members 2^1b of the frame 2^1. The concrete in the frame 2^1 keys well into the rough top face of the plaster base 14, irrespective of whether the concrete be poured on to the plaster base 14 while this is still green or after the plaster base 14 has set. Similarly, the concrete in the frame 2^1 forms a firm bond with the bottom rims of the liners 3^1. Because of the trapezoidal shape of the liners, they cannot in any circumstances be pulled up out of the frame 2^1. The bond between the liners 3^1 and the members of the frame 2^1 is further improved by the end portions 9^1aa of the liner reinforcements 9^1, which project sideways from the bottom edges of the liners 3^1. The end portions 9^1a and 9^1aa are bent alternatively downwards and upwards, so that they engage respectively in the material of the plaster base 14 and in that of the members of the frame 2^1. The close linkage of the plaster base 14 to the frame 2^1 is further improved by the loops $16a$ in the rods 16 which are so placed that the loops $16a$ project between the liners 3^1 into the bers of the frame 2^1.

In the embodiment illustrated in Figures 5 to 10, in addition to transverse reinforcement (not shown) in the cross-members 2^1a of the frame 2^1, static reinforcement, consisting merely of longitudinal rods 4^1 is provided in the longitudinal members 2^1a. To complete the static reinforcement, further reinforcing rods are inserted subsequently, prior to the pouring of the concrete on site, into the spaces between the liners 3^1, where they are then encased in that concrete.

To ensure that the ceiling unit 1 is rigid enough to withstand conveyance and laying, concrete bridging connectors 17 (Figures 5 to 7) are provided to join the top edges of adjacent liners 3^1 together. The bridging connectors 17 are soundly anchored to the liners 3^1 by virtue of the fact that the reinforcements 9^1 of the liners 3^1 have loops 9^1b, which project upwardly and which are embedded in the bridging connectors 17. The bridging members 17 provide sufficient rigidity to the ceiling unit 1 to enable the ceiling unit 1 to be lifted and laid with the aid of simple lifting tackle, and can be used as an alternative to, or in combination with, the rods 4^1. They could also be used in combination with or as an alternative to the girders 4 in the Figure 1 embodiment, but the girders 4 themselves provide sufficient rigidity.

Another possible method of making the ceiling unit 2^1 rigid is indicated in the upper portion of Figure 5, where those walls of the liners 3^1 which are in alignment with one another are joined together by webs $18a$ and $18b$, which extend the full height of the liners 3^1. Holes 19 are provided in the base of the webs $18a$, $18b$ to enable the reinforcing rods to extend therethrough.

In the embodiments described the transverse spaces between the liners (i.e. the spaces above the cross-members $2b$ or 2^1b) can be wholly or partly filled with concrete during prefabrication to form transverse ribs and the space enclosed by the webs $18a$ and $18b$ can be filled with concrete at the same time. In the case of a ceiling unit 7 metres long, for example, all but one of the aforesaid transverse spaces can be filled with concrete at the prefabrication stage. The one remaining space accommodates the static transverse reinforcement and is left unfilled until the concrete is being poured on site. The invention is not limited to the examples illustrated here. It is also possible, of course, for separately prefabricated liners to be fixed to a concrete frame, without the use of any plaster base, to form a ceiling unit. Irrespective of whether the liners and frame have been made separately or together, it is equally possible, when nailing battens 7 are provided, for a plaster or other base to be nailed to the ceiling unit and plastered. When the frame and liners are being made in one, another possibility is to fit a removable negative form above the forming table as well, such that just enough space for the ceiling unit is left between it and the moulds and table. The space can then be filled with concrete with the aid of a vibrator, numbered 13 in Figure 4. The nature of the reinforcement used, as such, is a matter of choice and can be suited to static requirements. It is important, however, that the ceiling unit be provided during the prefabrication stage, either by suitable reinforcement or with the aid of bridging members or stiffening webs, with sufficient rigidity to enable it to be readily transported and to be laid with few, if any, erection supports. Essential or addi-

tional members of the reinforcement used may naturally be fitted on site, before the concrete is poured.

The ceiling unit particularly described is relatively large in area but fairly low in weight, by virtue of the frame construction and the thin-walled liners. Being adequately stiffened, it can be transported to the site and there laid without great effort or expense. All that remains to be done on site then is to concrete it in and possibly also to place whatever reinforcement may not already have been included in the prefabricated unit.

When the liners themselves are prefabricated separately from the concrete frame, it is possible to dispense with the large number of separate moulds that would otherwise be required since the liners can then be made from a single mould. Prefabricated liners made of concrete have particular advantage, because the entire ceiling unit 1 is then of substantially monolithic construction made throughout from the same comparatively cheap material.

In many cases, the underside of the prefabricated ceiling unit will meet the necessary requirements as regards appearance and surface finish. Where a smooth underside is desired, a plaster base can be nailed or hooked onto the nailing battens on site and then rendered with plaster, although the embodiment in which the plaster base is prefabricated with the ceiling unit is more advantageous since the work required on site is less. This latter embodiment is further advantageous in that the reinforcing bars and rods inserted in the ribs are particularly well protected from rust, because they are shielded from below and at the sides not only by the concrete frame, but also by the plaster base and the liners. Good rust protection is afforded from above, in any case, by the concrete poured on site. When at least some of the transverse spaces between the liners are wholly or partially filled with concrete during the prefabrication of the ceiling units to form transverse ribs, the unit will have considerable transverse strength. If the said spaces be filled not quite to the level of the upper walls of the liners a "shoulder" will be provided to ensure a good key between the ceiling unit and the concrete poured on site. When the unit is reinforced by the webs, the webs can extend only transversely so that each transverse rib is uninterrupted across the width of the unit.

Although the above description has referred to single ceiling units, it will of course be appreciated that a plurality can be erected side by side and/or end to end, thereby providing a large area onto which in situ concrete can be poured.

WHAT I CLAIM IS:—

1. A method of producing a reinforced concrete ceiling comprising the steps of: forming at least one prefabricated ceiling unit which includes a concrete frame having longitudinal members and cross members defining a plurality of spaces, and hollow bodies which have upper and side walls and which are located over the spaces and are secured to adjacent longitudinal and cross members, and which has been reinforced to permit conveyance thereof prior to erection; erecting said at least one ceiling unit; and pouring concrete at least between adjacent bodies before or after erection of said at least one ceiling unit.

2. A method as claimed in claim 1, in which moulds for the bodies are laid on a forming table, and are spaced apart according to the width of the longitudinal and cross-members in the concrete frame, the said frame and the bodies being moulded in concrete applied between and over the moulds.

3. A method as claimed in claim 1, in which said bodies are prefabricated, said bodies are laid on a forming table and are spaced apart according to the width of the longitudinal cross-members in the concrete frame, the said frame then being moulded in concrete applied between the bodies.

4. A method as claimed in claim 3, in which a relatively thin plaster base is formed on the forming table, the prefabricated bodies are laid on the plaster base before it has completely set, and the concrete is applied between the bodies so as to be firmly bonded to the plaster base.

5. A method as claimed in any one of claims 1 to 4, in which reinforcing means is embedded in the longitudinal members of the frame.

6. A method as claimed in claim 5, in which the reinforcing means comprises girders having a top flange and bottom flange by which the ceiling unit is reinforced to permit conveyance, the bottom flange lying within the longitudinal member and the top flange lying within, or projecting above, the space between the adjacent bodies.

7. A method as claimed in claim 6, in which the girders are of welded lattice construction.

8. A method as claimed in any one of claims 1 to 7, in which reinforcing rods are embedded in cross-members of the frame.

9. A method as claimed in any one of claims 1 to 8, in which reinforcement means is incorporated in the bodies.

10. A method as claimed in claim 9, in which the reinforcement means in the bodies extends outwardly along edges of the bodies, forming projections which are embedded in the longitudinal and cross-members of the frame.

11. A method as claimed in claim 4, in

which a mesh of wires is embedded in the plaster base.

12. A method as claimed in claim 4, in which rods embedded in the plaster base have projecting loops which are embedded in the frame.

13. A method as claimed in any one of claims 1 to 12, in which the ceiling unit is reinforced by bridging members which extend between the upper walls of adjacent bodies.

14. A method as claimed in claim 13, in which reinforcement means in the bodies have portions which project from the body into the bridging member.

15. A method as claimed in any one of claims 1 to 12 in which the ceiling unit is reinforced by webs extending between the side walls of adjacent bodies and in alignment therewith.

16. A method as claimed in claim 15, in which the webs contain openings which receive reinforcing bars.

17. A method as claimed in any one of claims 1 to 14, in which at least some of the transverse spaces between the adjacent bodies are wholly or partially filled with concrete during formation of the ceiling unit.

18. A prefabricated ceiling unit for forming at least a part of a concrete ceiling, said unit comprising a concrete frame having longitudinal members and cross-members defining a plurality of spaces, and hollow bodies which have upper and side walls, and which are located over the spaces and are secured to the adjacent longitudinal and cross-members, and a reinforcement to permit conveyance and erection of the ceiling unit.

19. A ceiling unit as claimed in claim 18, in which the bodies are formed from concrete and are integral with the frame.

20. A ceiling unit as claimed in claim 18, in which the bodies are made from a material other than concrete.

21. A ceiling unit as claimed in any one of the claims 18 to 20, in which the underside of the frame carries a plaster base.

22. A ceiling unit as claimed in any one of claims 18 to 21, in which the longitudinal members of the frame contain reinforcing means.

23. A ceiling unit as claimed in claim 22, in which the reinforcing means comprises a girder having top and bottom flanges, the bottom flange being embedded in the longitudinal frame member.

24. A ceiling unit as claimed in claim 23, in which the girder is of welded lattice construction.

25. A ceiling unit as claimed in any one of claims 18 to 24, in which the cross-members of the frame contain reinforcing means.

26. A ceiling unit as claimed in any one of claims 18 to 25, in which the bodies contain reinforcing means.

27. A ceiling unit as claimed in claim 26, in which the reinforcing means of the bodies are anchored to the frame by projections from their bottom edges.

28. A ceiling unit as claimed in claim 21, in which the plaster base contains a reinforcing mesh.

29. A ceiling unit as claimed in claim 21 or claim 28, in which the plaster base contains rods having portions which project upwardly and are anchored in the frame.

30. A ceiling unit as claimed in claim 28 or 29, in which the said reinforcement comprises bridging members which extend between adjacent bodies.

31. A ceiling unit as claimed in claim 30 and in which reinforcing means in the bodies have portions which project from the bodies and are anchored to the bridging members.

32. A ceiling unit as claimed in any one of claims 18 to 29, in which the said reinforcement comprises webs extending between the side walls of adjacent bodies and in alignment therewith.

33. A ceiling unit as claimed in claims 32, in which the webs contain openings for reinforcing rods.

34. A ceiling unit as claimed in any one of claims 18 to 27, in which nailing battens are provided in the underside of the longitudinal members of the frame.

35. A ceiling unit as claimed in any one of claims 18 to 34, in which the frame has a peripheral supporting flange.

36. A ceiling unit as claimed in any one of claims 18 to 35, in which at least some of the spaces between the adjacent bodies are partly or wholly filled with concrete.

37. A method of producing a reinforced concrete ceiling substantially as hereinbefore described with reference to the accompanying drawings.

38. A reinforced concrete ceiling produced by the method claimed in any one of claims 1 to 17 or claim 37.

39. A prefabricated ceiling unit substantially as hereinbefore described with reference to the Figures 1—4, or Figures 5—10, of the accompanying drawings.

40. A reinforced concrete ceiling and/or floor structure, including at least one prefabricated unit as claimed in any one of claims 18—36 or claim 39, onto which in situ concrete has been poured, said structure being substantially as described herein.

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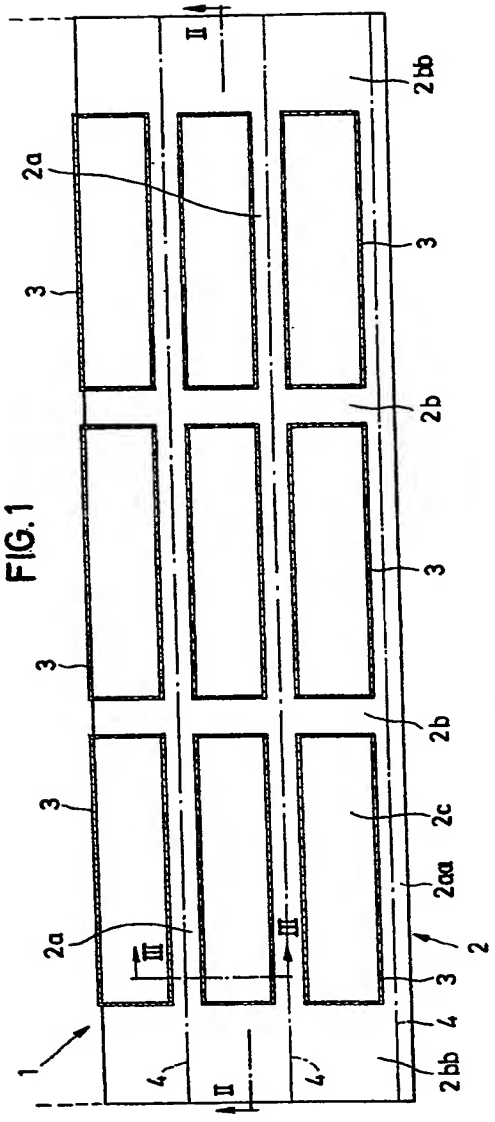
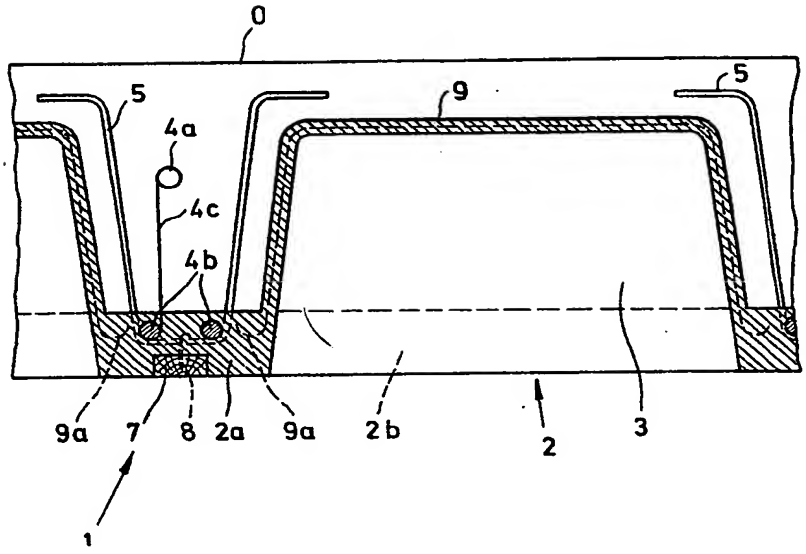


FIG. 3



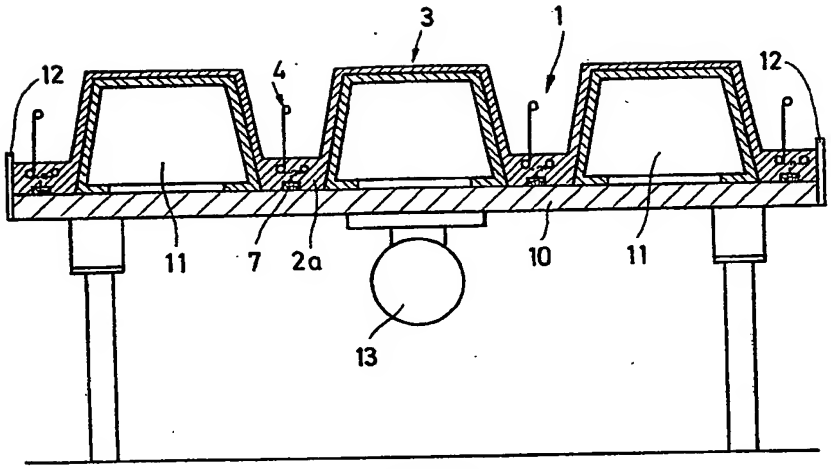


FIG. 4

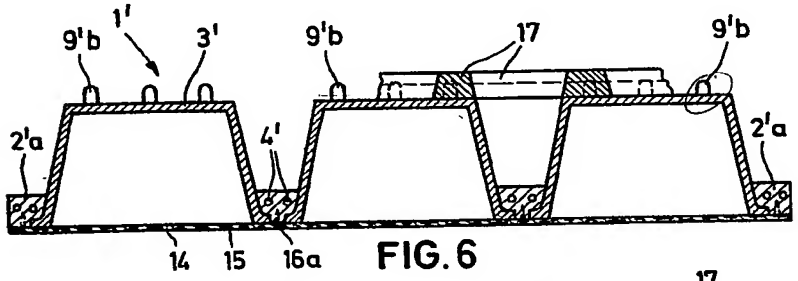


FIG. 6

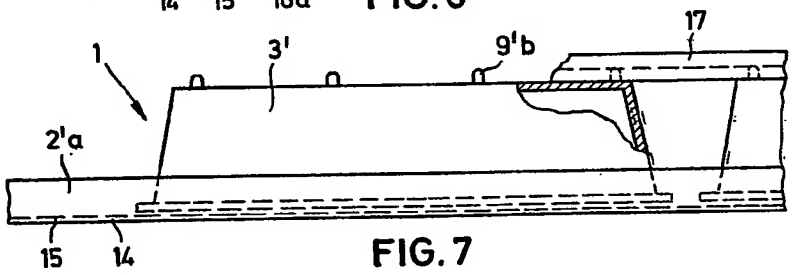


FIG. 7

FIG. 5

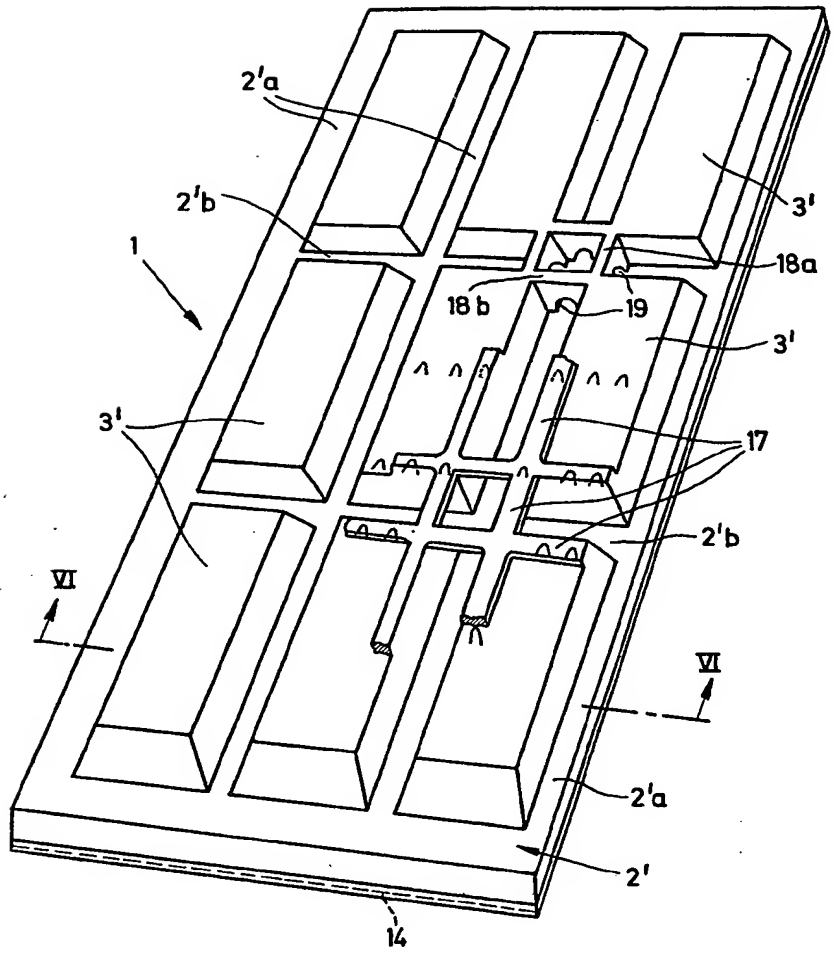


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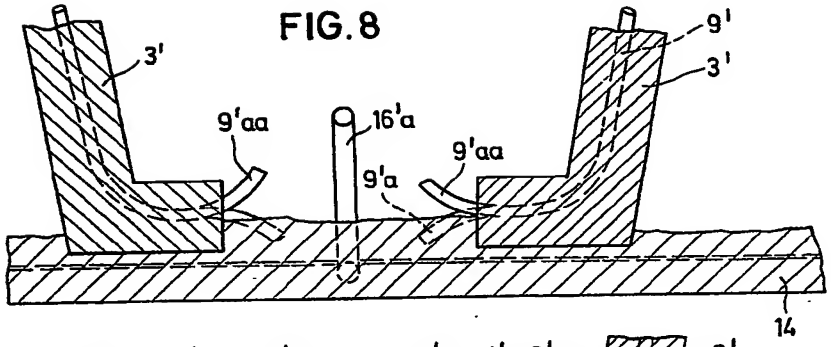
FIG.8



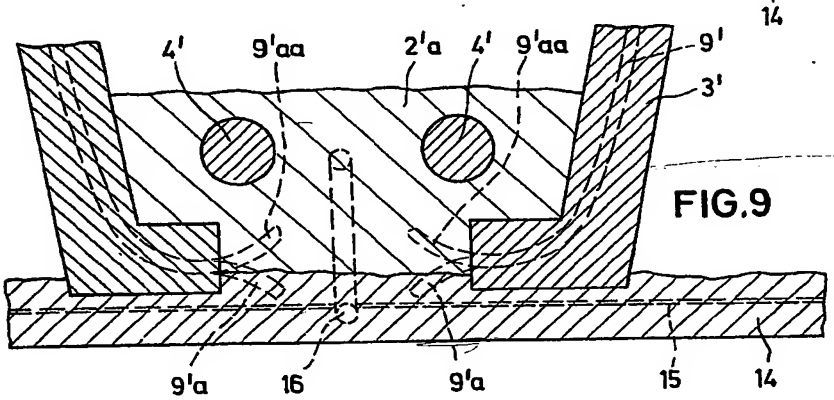


FIG.9

FIG.10